

## **Recent Studies of Interest and Their Implications for the Uinta Basin**

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Recently several journal articles have looked at potential methane emissions from various specific aspects of oil and gas production. These include areas where consensus has yet to be reached on the methane emissions impact each of these categories plays. These include processes such as liquid unloadings, the use of pneumatic controllers, and plugged and abandoned wells. This paper includes a brief overview of three recent methane emission studies and a summary of their findings. Additionally, it also looks at the implications each of these studies has on our understanding of emissions from our local oil and gas production region in the Uinta Basin.

### **Study #1**

**Allen, David T., David W. Sullivan, Daniel Zavala-Araiza, Adam P. Pacsi, Matthew Harrison, Kindal Keen, Matthew P. Fraser, A. Daniel Hill, Brian K. Lamb, Robert F. Sawyer, and John H. Seinfeld. 2014. "Methane Emissions from Process Equipment at Natural Gas Production Sites in the United States: Liquid Unloadings." doi: 10.1021/es504016r.**

### **What is liquid unloading?**

Liquid unloading is necessary when a gas well that also produces oil or water accumulates liquids in the well bore. This can be caused by decreased gas velocity in the well, decreased reservoir pressure, or changing gas to liquid ratios. As liquids accumulate well production declines, producers can use liquid unloading to restore production.

There are several methods of liquid unloading:

- 1) Tubing can be modified to increase gas velocity
- 2) A pump can be installed to remove downhole liquids  
(Neither #1 nor #2 lead to venting emissions, and are not the focus of the study)
- 3) Temporarily diverting the flow from the well to an atmospheric vent  
(#3 does lead to venting emissions, and is the method that is the focus of the study)

### **What did the study look at?**

- Wells with and without plunger lifts across 4 main regions: Appalachian, Rocky Mountain, Gulf Coast, Mid-Continent.
- Reports emissions from 107 natural gas wells w/liquid unloading emissions
  - 25 wells with auto plunger lift
  - 50 wells with manual plunger lift

- 32 wells without plunger lift
- In the Uinta Basin:
  - 8.9% of total Basin emissions are accounted for by companies providing sampling sites.
  - 25.6% of total Basin wells that had unloadings accounted for by companies providing sampling sites.

### **What was discovered?**

- Wells without plunger lift unload <10 times/year and can produce 21,000 to 35,000 scf methane/unloading event.
- Wells with plunger lift can unload 1000's of times/year and can produce 1000 to 10,000 scf methane/unloading event (These account for majority of emissions from liquid unloading).
- The study estimates that liquid unloading accounts for 270 Gg Methane/yr, 95% confidence range of 190-400 Gg. This estimate is within a few percent of the emissions estimated by the Environmental Protection Agency (EPA) 2012 Greenhouse Gas National Emission Inventory (GHG NEI) released in 2014 (dominated by wells with high frequency of unloading).
- The estimated emissions from liquid unloadings are spatially concentrated in the Rocky Mountain production region. Wells in this region account for more than half of the estimated emissions from liquid unloadings in the 2012 Greenhouse Gas Reporting Program.
- There is a temporal distribution to liquid unloading: some wells release many times per day, while others are only once per year or once per the life of the well. Some only release for a portion of their production lifecycle (dependence on well age).
- A small fraction of wells that vent account for the majority of emissions.
  - Wells without plunger lift: 3% wells accounted for 50% of emissions, 50% of wells accounted for 90% of emissions.
  - Wells with plunger lift: less than 50% of wells account for >90% of emissions.
- Actual venting values are as follows:
  - Wells without plunger lift:
    - Venting lasted for between 0.17 and 4.5 hr, volumes ranged from 550 to 135,000 scf/event
  - Wells with manual plunger lift
    - Venting lasted for between 0.03 and >3 hr, volumes ranged from 200 to 49,000 scf/event
  - Wells with auto plunger lift
    - Venting lasted for between <1 min to >20 min, volumes ranged from 50 to >8,000 scf/event

### **Methods:**

- Venting was measured one of two ways:
  - By directing flow through temporary stack installed on top of vent of atmospheric tank, measured continuously with thermal gas mass flow meter.

- On some wells (31 of 107) measurement through temporary stack was not feasible. Instead they inserted a segment of pipe into the process line between separator and atmospheric tank to determine flow into the tank (this is actually a more accurate method).
  - The same methods were used regardless of lift type, but for wells with automatic plunger lift, they left the measuring devices in place for several days to capture events as they occurred rather than forcing an unloading event.
  - Sampling Goals:
    - 1) Sample at least 3 companies in each major region.
    - 2) Sample basins with largest reported emissions (according to EPA GHGRP).
    - 3) Sample each off the participant companies at least once.
- Note: They were more likely to sample sites that unloaded more often.

### **Implications for the Uinta Basin:**

Utah Division of Air Quality (UDAQ) currently has limited information on liquid unloading for the Uinta Basin. Emissions for well blowdowns (venting of the well to the atmosphere, see method 3 above) were estimated in the Western Regional Air Partnership's (WRAP) Phase III emission inventory (EI), using survey responses and extrapolating the data to basin-wide emissions. The estimates were made by using an estimated volume of gas vented during blowdown event of 7,650 scf/event, a frequency of blowdowns, and an averaged gas composition of the vented gas. The fraction of methane in the vented gas during blowdown was estimated to be 0.78, using this factor it is estimated that each blowdown event produced approximately 5,967 scf of methane. This within the range noted in the Allen et al. study, however given the wide range of emissions per unloading event noted in the study (50 to 135,000 scf methane/event) it may be beneficial to have more specific emissions information for each blowdown event in the Basin rather than an average. In 2013, according to well data from Division of Oil, Gas, and Mining (DOGM), there were 7,936 producing and shut-in gas wells in Utah (1,921 on state jurisdiction and 6,015 on Indian country/tribal and reservation land). This means that there are potentially a large number of wells which may potentially utilize liquid unloading. Additionally, the above study specifically points out that the emissions from liquid unloadings are spatially concentrated in the Rocky Mountain region. This is an emissions category UDAQ would like to look closer at in the future. It would be beneficial to gather further information about liquid unloadings either via WRAP's upcoming oil and gas survey, or through future annual oil and gas emission inventories.

### **Study #2**

**Allen, David T., Adam P. Pacsi, David W. Sullivan, Daniel Zavala-Araiza, Matthew Harrison, Kindal Keen, Matthew P. Fraser, A. Daniel Hill, Robert F. Sawyer, and John H. Seinfeld. 2014. "Methane Emissions from Process Equipment at Natural Gas Production Sites in the United States: Pneumatic Controllers." doi: 10.1021/es5040156.**

**What are pneumatic controllers?**

Pneumatic controllers use gas pressure to control the operation of mechanical devices, such as valves. The valves control process conditions such as levels, temperatures, and pressures. When a controller identifies the need to change liquid level, pressure temperature, or flow, it will open or close a control valve in order to return to a desired set point. Controllers can be either discrete (on/off) or proportional in magnitude (throttling). They can either work through continuous venting or intermittent venting of gas, so they can be grouped into four types based on the type of service and type of venting. EPA recognizes three types: low continuous bleed, high continuous bleed, and intermittent.

#### **What did the study look at?**

- Reported emissions from 377 gas actuated pneumatic controllers.
- Explored a wider population of wells than previous studies. 65 sites total, geographically distributed across the U.S. Include conventional and shale gas wells (351), and some oil wells (26).
- Mainly focused on continuous vent or intermittent vent pneumatic controllers.
- The study also characterized the features of the high emission controllers.

#### **What was discovered?**

- A small subset of the pneumatic devices accounted for the majority of emissions:
  - 19% of devices accounted for 95% of emissions
- More than 50% of the controllers measured recorded emissions of 0.001 scf/hr or less during 15 minutes of measurement.
- Controllers in level control applications on separators and in compressor applications had higher emission rates than controllers in other types of applications.
- The lowest emissions were measured in the Rocky Mountain region and the highest emissions were measured in the Gulf Coast.
- The average methane emissions found in the study, 4.9 scf/h (5.5 scf/h whole gas), are 17% higher than the average emissions per controller in the 2012 EPA GHG NEI (released in 2014). This is much closer than the emissions noted in previous studies U.S> 10.5 scf/h methane and B.C and Alberta 9.2 scf/h whole gas (Allen et al. 2013 and Prasino Group 2013).
- The study found an average of 2.7 controllers per well, compared to 1.0 controllers per well reported in the 2012 GHG NEI, (may indicate need for improved counts in NEI).
- When examining similarities between the 40 controllers with the highest emissions rates, it was determined that:
  - Many were behaving in a manner inconsistent with manufacturer's design.
  - Many of them had repairable issues.

#### **Methods:**

- Random sampling of participant sites.
- For each well visited, all the controllers on the site were measured using gas meters, unless operating conditions, etc. prevented it.

- 333 controllers were measured with a supply gas meter, 97 couldn't be measured this way, 44 of those were then measured using exhaust gas measurements (377 total).
- Measurements were taken over a 15 min. sampling period (could have missed emissions from devices that actuate less than 4 times/hour.)
- Different sampling method for this study than previous studies (Allen et al. 2013; Prasino Group 2013) many zero and low emitting controllers were included (all controllers were measured regardless of whether they would be reported through EI) such as emergency shut-down controllers (ESD).
- For devices with no emissions detected over the 15 minute sampling period, the average emission per actuation was calculated for controllers in each application. The average emissions per actuation were multiplied by an estimated frequency of actuation.

### **Implications for the Uinta Basin:**

Utah Division of Air Quality (UDAQ) does not have actual pneumatic controller counts for the Uinta Basin. We have estimated counts based on back calculations of the 2012 WRAP Phase III EI Projection. UDAQ looked at both the EPA suggested adoption rate noting 34% of controller in the field being low-bleed (1146), and 66% being high bleed (2225) for a total of 3371 controllers in the field, as well as the UDAQ Compliance suggested adoption rate, noting 10% of controllers on the field as being low-bleed (251) and 90% as being high bleed (2258), for a total of 2509 controllers in the field<sup>1</sup>. In both cases it was assumed that high bleed controllers had average whole gas bleed rate of 37.3 scf/hr and 1.39 scf/hr respectively (U.S. National Archives and Records Administration, 2012). This works out to an average bleed rate per controller in the Basin of between 25.09 scf/hr (34%/66% ratio) and 33.71 scf/hr (10%/90% ratio), both of which are higher than the average bleed rate estimated in the above study and previous studies Allen et al. 2013 and Prasino Group 2013. The 2012 WRAP Phase III EI projection included 1680 non-tribal oil wells. If using the 34%/66% breakdown, each well would average a count of 2.01 controllers and using the 10%/90% breakdown, each well would average 1.49 controllers. Both of these estimates are lower than those estimated in the above study, but higher than those estimated in the 2012 GHG NEI. Given the variation in the reported average bleed rate of pneumatic controllers in various studies and the count of controllers per site, UDAQ has a strong need to collect an improved inventory of pneumatic controllers and their specific emissions. Additionally the numbers presented here just look at the pneumatic controllers related to oil production on state jurisdiction, even more controllers would be added if those associated with gas production or located on tribal jurisdiction were included. This makes an even stronger case for the need to better understand the emissions related to this source category.

### **Study #3**

**Kang, Mary, Cynthia M. Kanno, Matthew C. Reid, Xin Zhang, Denise L. Mauzerall, Michael A. Celia, Yuheng Chen, and Tullis C. Onstott. 2014. "Direct measurements of methane emissions from abandoned oil and gas wells in Pennsylvania." doi: 10.1073/pnas.1408315111.**

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<sup>1</sup> Note: These values are derived from 2012 projections of 2006 UB WRAP Phase III EI, and these values are only for Uintah and Duchesne counties and only include emissions from oil wells on state jurisdiction.

### **What did the study look at?**

- Direct measurements of methane fluxes from abandoned oil and gas wells in Pennsylvania using static flux chambers.
- Made measurements from 19 wells in various locations. 5 of the 19 were classified as plugged, based on surface evidence or presence of marker.
- A total of 42 direct measurements were taken at wells and 52 direct measurements were taken at locations near wells in forested, wetland, grassland, and river areas during July, August, October 2013 and January 2014.

### **What was discovered?**

- The mean flow rate at abandoned wells was determined to be 0.27 kg/d/well.
- The mean flow rate at control locations was determined to be  $4.5 \times 10^{-6}$  kg/d/location.
- 3 of the 19 wells were large emitters with flows three orders of magnitude larger than the median flow rate of  $1.3 \times 10^{-3}$  kg/d/well.
- Assuming the mean flow rate is representative of all the abandoned wells in Pennsylvania; the scaled emissions would be 4-7% of total anthropogenic methane emission in the state.
- The study determined that the measured methane was predominantly thermogenic in origin (according to presence of ethane, propane, n-butane, along with methane and enriched  $^{13}\text{C}$  samples at wells).
- Positive methane flow rates were observed at all 19 wells.
- The flow rates at wells seemed to be unaffected by land cover, but controls seemed to be affected.
- The flow rates from controls seemed to have a seasonal effect, but this doesn't seem to be the case with wells, however further study is needed.
- The methane flow rates from plugged wells were not necessarily lower than methane flow rates at unplugged wells.

### **Methods:**

- Measurements made using static chamber technology, designed to enclose the wellhead.
- Measurements at one to six control locations, between 0.1-62 m from the measured well, were also taken.
- Ethane, Propane, and n-Butane measurements were also taken in order to look at methane origin (utilized flame ionization gas chromatography). Because ethane is not coproduced during microbial methanogenesis ethane-to-methane ratios  $>0.01$  indicate gas mainly of thermogenic origin. The study also assumed this to be true for ethane-to-propane, and ethane-to-n-butane ratios.
- $^{13}\text{C}$  measurements were also looked at to determine methane origin (utilized near-IR continuous wave-cavity ring-down spectrometer), the study notes that methane originating from thermogenic sources is more enriched in  $^{13}\text{C}$  than that from microbial sources.

**Implications for the Uinta Basin:**

According to data from the DOGM database, as of December 22, 2014 there are 7,541 plugged and abandoned wells in Utah. This is also an area in which UDAQ has essentially no specific emissions information. Given the large number of plugged and abandoned wells in Utah, this warrants study in the Uinta Basin, especially since the Kang et al. study found this source to be relatively large portion, 4-7% of total anthropogenic methane emissions in Pennsylvania.

**References**

Allen, D. T.; Torres, V. M.; Thomas, J.; Sullivan, D.; Harrison, M.; Hendler, A.; Herndon, S. C.; Kolb, C. E.; Fraser, M. P.; Hill, A. D.; Lamb, B. K.; Miskimins, J.; Sawyer, R. F.; Seinfeld, J. H. Measurements of methane emissions at natural gas production sites in the United States. *Proc. Natl. Acad. Sci. U.S.A.* **2013**, 110, 17768–17773.

Prasino Group. *Final Report for determining bleed rates for pneumatic devices in British Columbia. Report to British Columbia Ministry of Environment*, December 2013.

U.S. National Archives and Records Administration. 2012. Code of Federal Regulations, Title 40 Section 98.233, Calculating GHG Emissions, 75 FR 74488, November 30, 2012, as amended at 76 FR 80575, December 23, 2011.